Hadron multiplicities, p_T spectra and net-baryon number in central Pb+Pb collisions at the LHC

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We summarize here our recent LHC predictions [1], obtained in the framework of perturbative QCD (pQCD)+saturation+hydrodynamics (EKRT model for brief) [2]. This model has successfully predicted [2, 3] the charged particle multiplicities in central Au+Au collisions at different $\sqrt{s}$, and it also describes the low-p_T spectra of pions and kaons at RHIC quite well [1, 4].

Primary parton production in the EKRT model is computed from collinearly factorized pQCD cross sections [5] by extending the calculation towards smaller p_T until the abundant gluon production vertices overlap and gluon fusions [6] saturate the number of produced partons (gluons). The saturation scale is determined as $p_0 = p_{\rm sat}$ from a saturation condition [2] $N_{AA}(p_0, \sqrt{s}) \cdot \pi/p_0^2 = c \cdot \pi R_A^2$, where $N_{AA}(p_0, \sqrt{s})$ is the average number of partons produced at $|y| \leq 0.5$ and $p_T \geq p_0$. With a constant $c = 1$ the framework is closed. For central Pb+Pb collisions at the LHC $p_{\rm sat} \approx 2$ GeV. We obtain the initial conditions for the cylindrically symmetric boost invariant 2+1-D hydrodynamical description by converting the computed transverse energy $E_T(p_{\rm sat})$ and net-baryon number $N_B(p_{\rm sat})$ into densities $\epsilon(r, \tau_0)$ and $n_B(r, \tau_0)$ using binary collision profiles and formation time $\tau_0 = 1/p_{\rm sat}$.

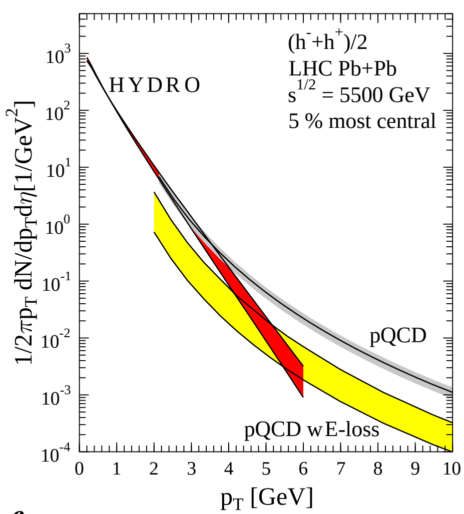
Assuming a fast thermalization at τ_0, and zero initial transverse fluid velocity, we proceed by solving the standard equations of ideal hydrodynamics including the current conservation equation for net-baryon number. In the Equation of State we assume an ideal gas of gluons and massless quarks ($N_f = 3$), the QGP, with a bag constant B at $T > T_c$, and a hadron resonance gas of all states with $m < 2$ GeV at $T < T_c$. Taking $B^{1/4} = 239$ MeV leads to 1st-order transition with $T_c = 165$ MeV. Final state hadron spectra are obtained with Cooper-Frye procedure on a decoupling surface at $T_{\rm dec}$ followed by strong and electromagnetic 2- and 3-body decays of unstable states using the known branching ratios. Extensive comparison [1, 4] with RHIC data suggests a single decoupling temperature $T_{\rm dec} = 150$ MeV which is also used to calculate the predictions for the LHC. For details, see [1].

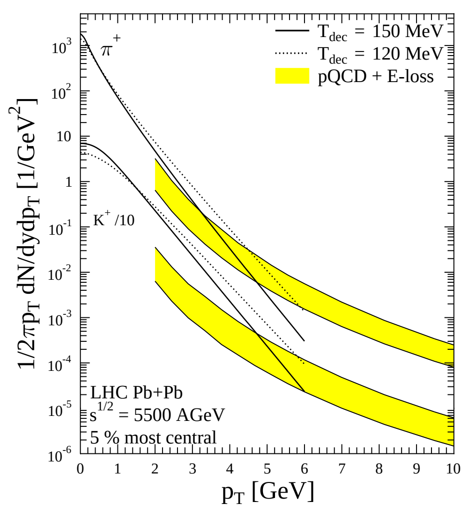
Our predictions [1] for the LHC multiplicities, transverse energies and net-baryon number at $y = \eta = 0$ for 5 % most central Pb+Pb collisions at $\sqrt{s} = 5.5$ TeV are summarized in the table below. Note that the predicted charged particle multiplicity $dN_{\rm ch}/d\eta$ is 2570, i.e. only a third of the initial ALICE design value (see also [3]).

Whereas the multiplicity of initially produced partons and observable hadrons are close to each other, the transverse energy is reduced by a factor as large as 3.4 in the evolution from initial state to final hadrons. Due to this reduction the very high initial temperature, $T_0 \gtrsim 1$ GeV, possibly observable through the emission of photons, need not lead to contradiction between predicted and observed E_T.

$\frac{dN}{dy}^{\rm tot}$	$\frac{dN}{d\eta}^{\rm tot}$	$\frac{dN}{dy}^{\rm ch}$	$\frac{dN}{d\eta}^{\rm ch}$	$\frac{dN}{dy}^{B}$	$\frac{dE}{dy}^{T}$	$\frac{dE}{d\eta}^{T}$	$\frac{dN}{dy}^{\pi\pm}$	$\frac{dN}{dy}^{\pi 0}$	$\frac{dN}{dy}^{K\pm}$	$\frac{dN}{dy}^{p}$	$\frac{dN}{dy}^{\bar{p}}$	$p/\bar{p}$
4730	4240	2850	**2570**	3.11	4070	3710	1120	1240	214	70.8	69.6	0.98

Our prediction for the charged hadron p_T spectrum is the lower limit of the red band (HYDRO, the width corresponding to $T_{\rm dec} = 120 \ldots 150$ MeV) in the l.h.s. figure below [1]. The corresponding p_T distributions of π^+ and K^+ are shown in the r.h.s. figure (solid lines). The pQCD reference spectra, obtained by folding the LO pQCD cross sections with the nuclear PDFs and fragmentation functions (KKP) and accounting for the NLO contributions with a $\sqrt{s}$-dependent K-factor from [7], are also shown (pQCD) on the r.h.s.. The yellow bands (pQCD w E-loss) show the results with parton energy losses included as in [8]. We thus predict the applicability region of hydrodynamics at the LHC to be $p_T \lesssim 4 \ldots 5$ GeV, i.e. a wider region than at RHIC.





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